

# TIPS TO TAKE YOUR TEAM TO THE TOP

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There are countless ways to improve constructability on your next project. Here are 50 of them.

**WE HEAR THE WORD "CONSTRUCTABILITY"** all the time—but what does it mean?

Simply put, constructability is the ease with which a structure can be built. Constructable designs are more economical structures because they provide options and flexibility before work has progressed and the die is cast.

The concept of constructability includes four main principles:

- ▶ Simplicity = Economy
- ▶ Least weight *does not always* = Least cost
- ▶ Fewer pieces = Greater economy
- ▶ Efficient connection design = Reduced cost

Since the best, most constructable solutions for a project often depend on local construction practices and contractor preferences, the recommendations of the construction team—including the fabricator and erector—can improve efficiency and economy and add value to your project early on and along the way. Below are 50 tips, separated by category, that can enhance the constructability of your next project. (Note: These tips are from the seminar "50 Tips for Designing Constructable and Economical Steel Buildings," presented at the 2011 and 2013 NASCC: The Steel Conference.)

## Connections

Tip 1: Design connections per the requirements of the building code and AISC 360 (and AISC 341 if it is applicable).

Tip 2: If delegating connection design work to an engineer working for the fabricator, do so properly with Option 3 in Section 3.1.2 in AISC 303-10, the *AISC Code of Standard Practice*.

Tip 3: And also, show the reactions, moments and axial forces from Tip 1 when using Tip 2.

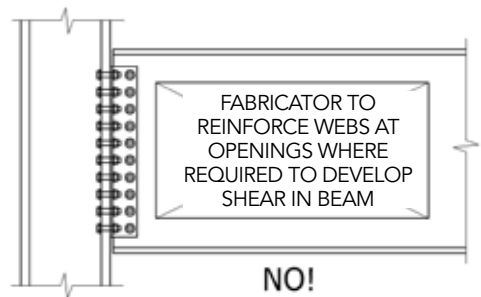
Tip 4: Provide load combinations and directions of reactions, moments and forces (Figure 1) at joints so the engineer

doing connection design can satisfy statics (always a plus!).

Tip 5: Provide sufficient information on the drawings to minimize uncertainty among bidders. Section 3 in the *AISC Code of Standard Practice* lists the typical information needed to get responsive and comparable bids.

Tip 6: Understand that fabricator preferences differ regarding preferred connection details; some like shear tabs, others like all-bolted single or double angles, etc.

Tip 7: Don't delegate design of reinforcing around beam web openings. Either eliminate the need for it or specify it on the design drawings. See *AISC Design Guide 2: Steel and Composite Beams with Web Openings* for more guidance (Figure 2).



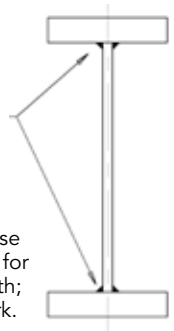
▲ Figure 2

▼ Figure 3

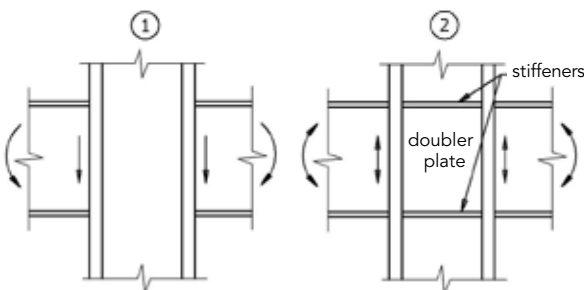
Tip 8: Don't delegate design of plate girder welds (Figure 3)

Tip 9: Think about how the connections will be configured and detailed, even when using Option 3 in the *AISC Code of Standard Practice*.

Do not delegate design of plate girder welds. (How does the fabricator know what the shear flow is?)



Also, do not make these welds CJP welds. Size for actual required strength; fillet welds usually work.



▲ Figure 1: Diagram 1 is typical for gravity; Diagram 2 is excessive if it isn't a real loading condition.

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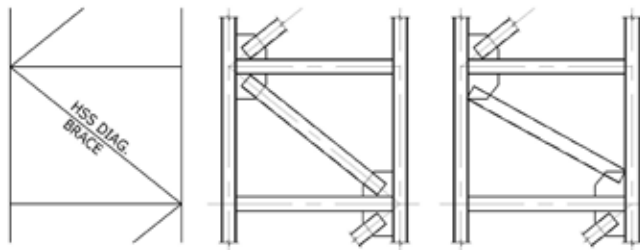
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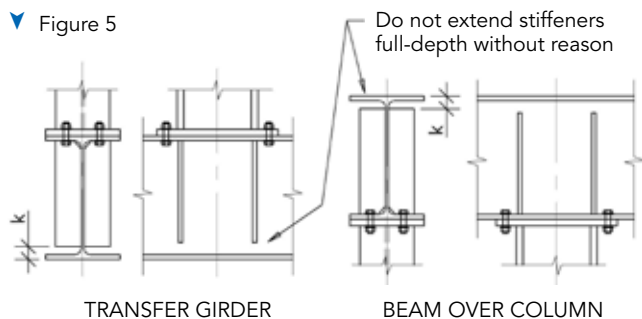


Tip 10: Verify that framing can be installed (Figure 4). Talk to a fabricator—they'll be happy you asked!



▲ Figure 4: Framing geometry may present installation challenges.

▼ Figure 5



Tip 11: Use one-sided shear connections (like single-angle and single-plate connections) to simplify field work, unless they can't provide the required strength.

Tip 12: Avoid full-depth stiffeners where possible. Eliminate them, and if they're unavoidable, consider if they can be detailed to avoid fitting the stiffener (see Figure 5).

## Bolting

Tip 13: Allow the use of bearing bolt strength values where slip-critical values are not required in the AISC and RCSC Specifications.

Tip 14: Permit the use of any diameter and type of bolt, but avoid mixing grades in the same diameter.

Tip 15: Permit the use of short-slotted holes, especially in shear connections with the load transverse to the slot.

Tip 16: Remember that all slip-critical bolted connections are pretensioned, but not all pretensioned bolts need to be slip-critical. AISC 360-10, Section J1.10 has a list of connections where pretensioned bolts (or welds) are required, but these are not slip-critical.

## Welding

Tip 17: Use fillet welds sized for required strength whenever possible. Overwelding increases volume and cost proportionally to the square of the weld size!

Tip 18: Avoid specifying arbitrary CJP groove welds and all-around fillet welds unless they are needed to achieve the required strength.

Tip 19: Favor fillet welds over groove welds.

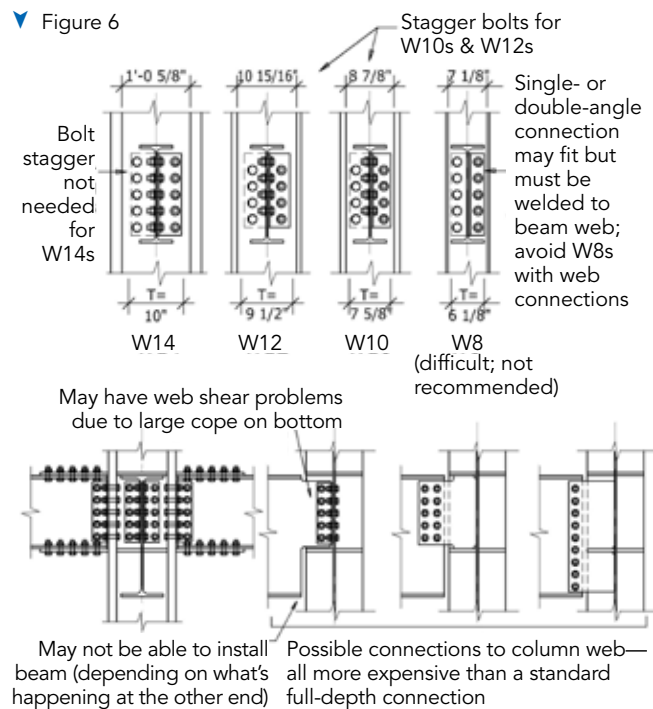
Tip 20: Strive to configure connection details with a flat or horizontal welding position.

Tip 21: Favor a longer  $\frac{5}{16}$ -in. (or smaller) fillet weld over larger fillet welds;  $\frac{5}{16}$  in. is the largest fillet weld size that can be made in one pass. Multi-pass welds are three to four times more expensive than single-pass welds.

## Columns

Tip 22: Use the deepest practical column; especially avoid W8 and smaller columns with connections to the web (Figure 6).

▼ Figure 6

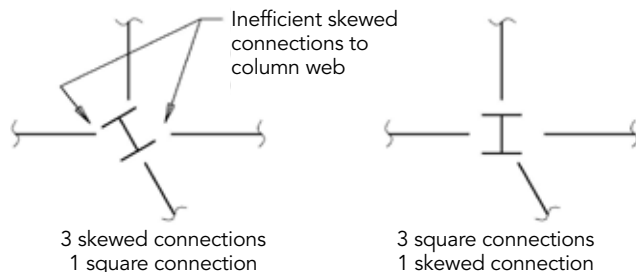


▲ Figure 7

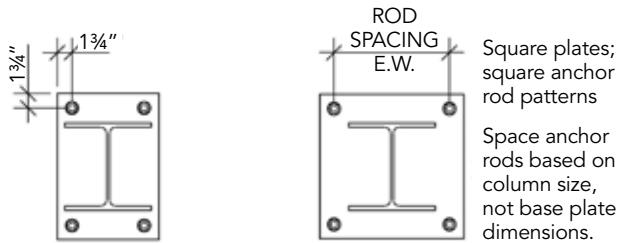
Tip 23: Size columns to eliminate the need for stiffeners, especially for the trapped double-angle connection illustrated in Figure 7, which cannot be installed.

Tip 24: Where column stiffeners can't be avoided, make the opposing beams the same depth, and consider the effect of the stiffeners on beams framing in the perpendicular direction.

Tip 25: Orient columns to minimize skewed connections (Figure 8 ▼).



Tip 26: Simplify base plates and anchor rod details (Figure 9).



Square plates; square anchor rod patterns  
Space anchor rods based on column size, not base plate dimensions.

Smallest base plate, but...

- ▶ Different anchor rod pattern for every base plate
- ▶ Unsymmetrical anchor rod pattern
- ▶ Fractional anchor rod spacing (based on base plate size)

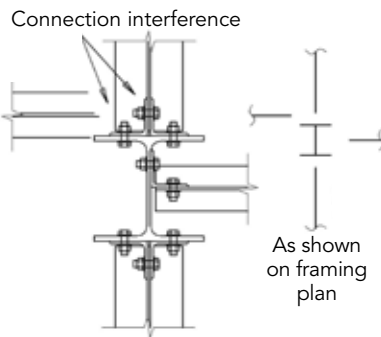
Largest base plates, but...

- ▶ Square plates
- ▶ Doubly symmetric anchor rod pattern and fewer different anchor rod patterns
- ▶ Easier to build

▲ Figure 9: Keep column base plates and anchor rod patterns square.

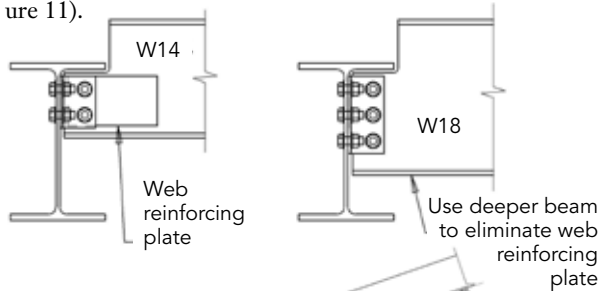
## Beams

Tip 27: Watch out for connection interference where beams are slightly offset from columns (Figure 10). Change the details or determine that the geometry can work before showing this on the design drawings; again, ask a fabricator, and they'll be glad you did.



▲ Figure 10

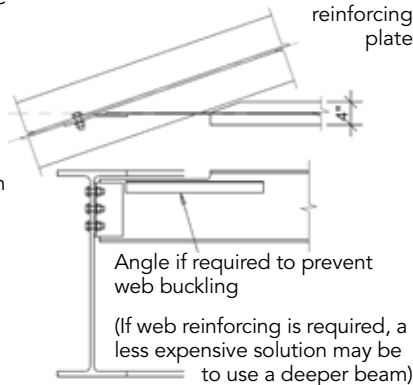
Tip 28: Increase beam depth to avoid web reinforcing (Figure 11).



▲ ▶ Figure 11

Possible situations requiring web reinforcing:

- ▶ Large copes with heavy reactions
- ▶ High beams framing to low girders
- ▶ Skewed beams with long copes

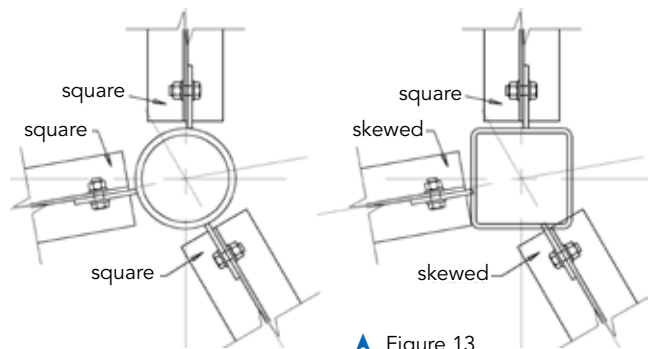


Tip 29: Size members to have sufficient strength at the net section. This usually can be accomplished by limiting the required strength to 75% of the gross section strength when the connection details are not known during member selection (Figure 12 ▼).

$$\text{Max. recommended stress ratio at gross section} = \frac{\text{Required strength}}{\text{Usable strength}} = 0.75 \text{ (max.)}$$

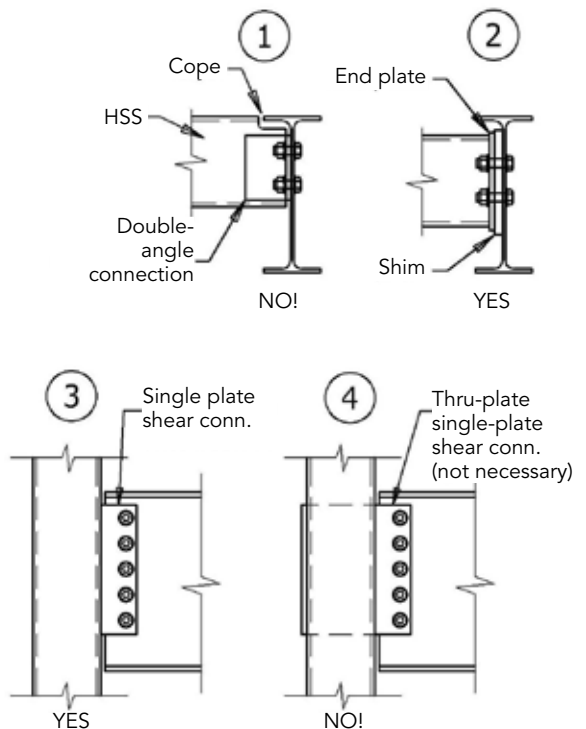
## Hollow Structural Sections (HSS)

Tip 30: Favor round HSS or steel pipe columns over square/rectangular HSS when there are skewed connections (Figure 13).



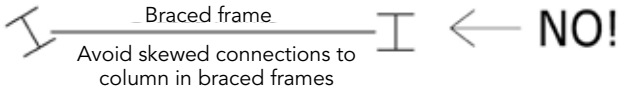
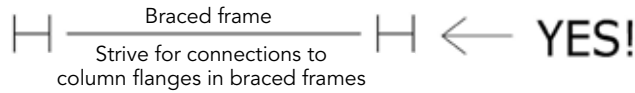
▲ Figure 13

Tip 31: Configure HSS framing to simplify connections (Figure 14 ▼).



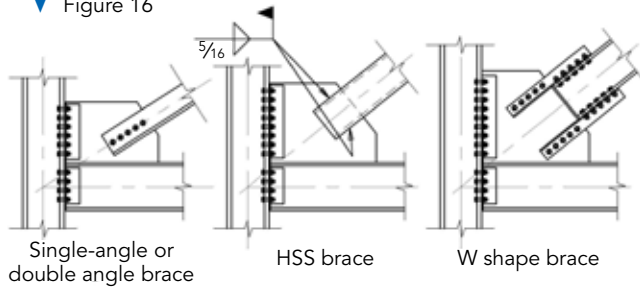
## Vertical Bracing

Tip 32: Orient columns square to the framing plan when they are part of a braced frame (Figure 15).



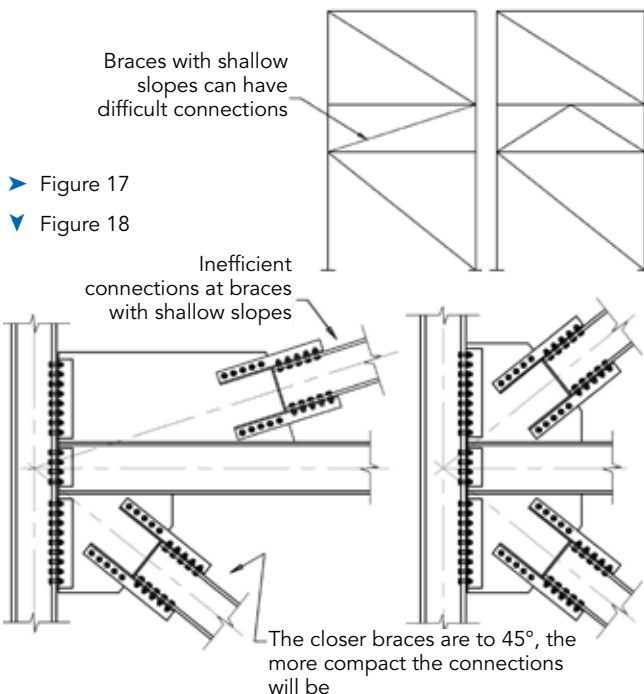
▲ Figure 15

▼ Figure 16



Tip 33: Select efficient diagonal braces: single-angles (good for small loads), double-angles (efficient connections), HSS (highest brace strength per pound of steel), W-shapes (connections can be more intricate than other brace types, Figure 16). When properly selected with good connection details, any brace type can be economical.

Tip 34: Configure slopes of diagonal braces between 35 and 55 degrees (Figures 17 and 18).

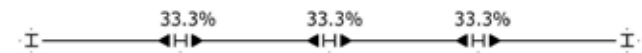
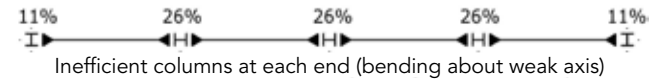
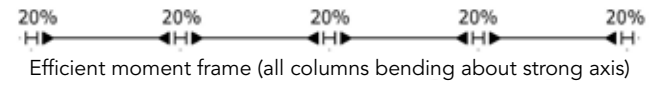


► Figure 17

▼ Figure 18

## Moment Connections

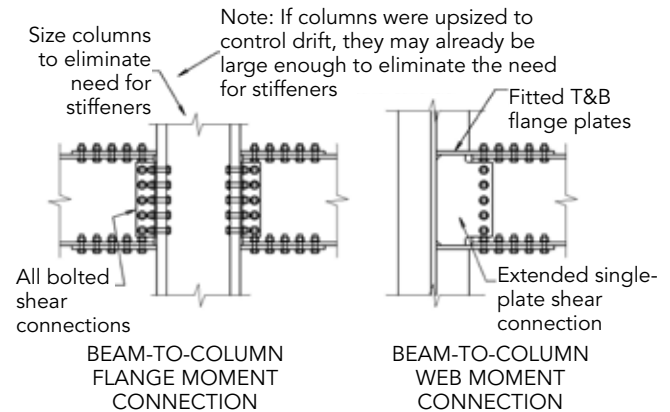
Tip 35: Orient columns in moment frames for strong-axis bending (Figure 19 ▼).



Where column orientation cannot be changed, consider eliminating weak-axis column moment connections. Weak-axis column moment connection details are often more complex than strong-axis column moment connection details

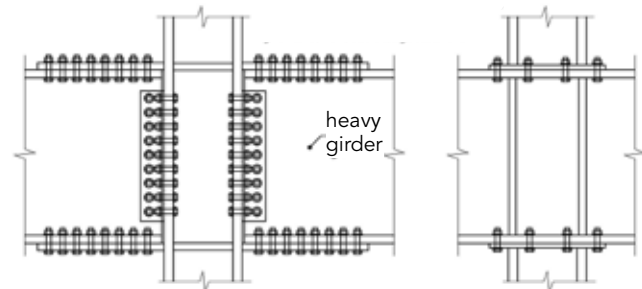
FOR 14"×14" W14 COLUMNS  $I_x/I_y > 2.5$

Tip 36: Strong-axis beam-to-column moment connections are generally less complex than weak-axis beam-to-column moment connections (Figure 20).



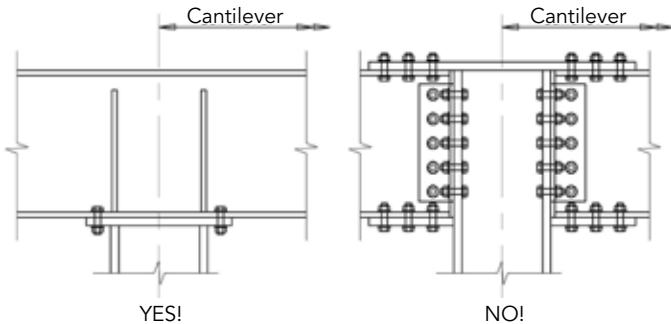
▲ Figure 20

▼ Figure 21: Where girder moments are big and column moments are small, consider running girders continuous through columns.



Tip 37: Consider making girders continuous through columns at heavy moment-connected girders to simplify flow of moment through columns (Figure 21). Ask the fabricator, since the gain needs to outweigh the difference in construction to make this tip viable.

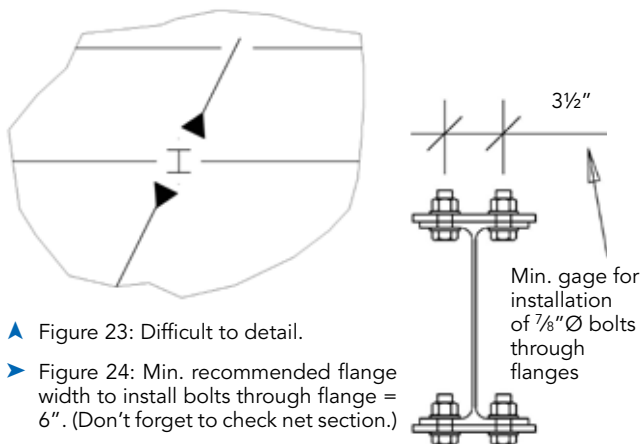
Tip 38: Run cantilevered roof beams over the tops of columns (Figure 22).



▲ Figure 22: Note: If roof framing slopes, coordinate so there's not a kink in the beam at the column.

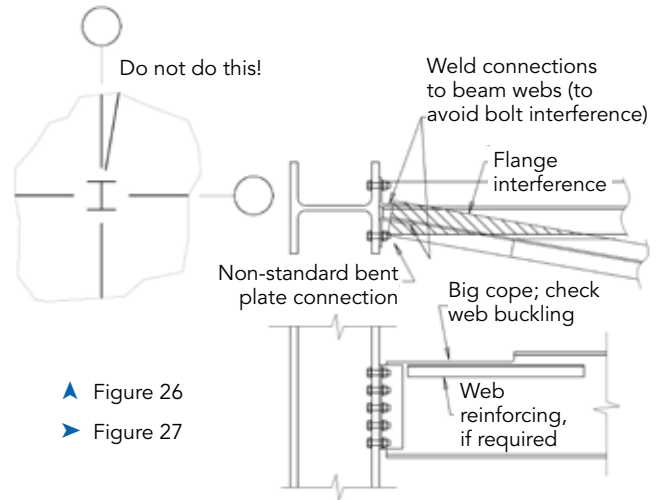
Tip 39: Avoid skewed beam-to-column moment connections (Figure 23).

Tip 40: Beams with flange-bolted moment connections must have sufficiently wide flanges to install bolts (Figure 24). Many light beams do not have wide enough flanges!



▲ Figure 23: Difficult to detail.  
 ▶ Figure 24: Min. recommended flange width to install bolts through flange = 6". (Don't forget to check net section.)

Tip 42: Configure framing so that no more than one beam frames to any one side of a column (Figures 26 and 27).

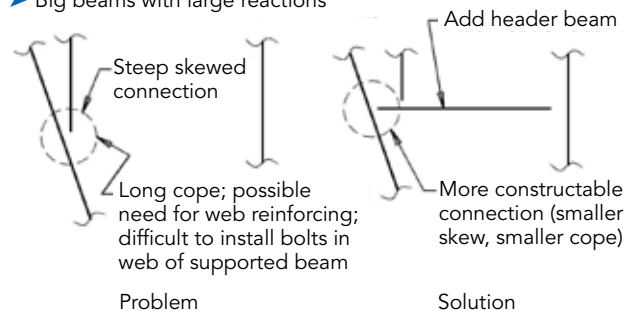


▲ Figure 26  
 ▶ Figure 27

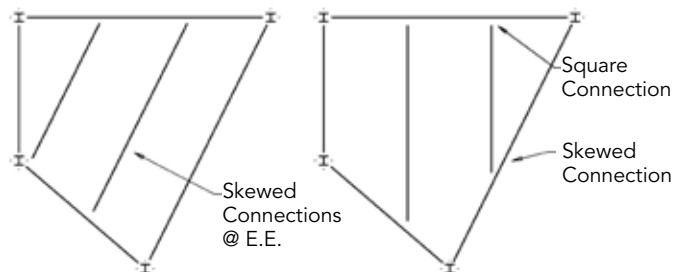
Tip 43: Head off steeply skewed connections (Figure 28 ▼).

Steep skewed connections can be a problem with,

- ▶ Small beams (long copes relative to depth)
- ▶ Big beams with large reactions

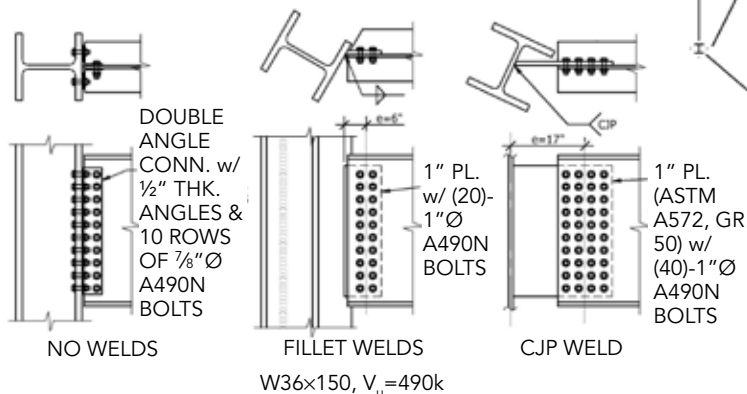


Tip 44: Configure framing to minimize skewed connections (Figure 29 ▼).



## Framing

Tip 41: Frame members with very large reactions square to columns—preferably to the flanges (Figure 25 ▼).



Tip 45: Configure framing to minimize the number of beams (Figure 30 ▶).

Tip 46: Maximize slab span to minimize the number of beams (Figure 31).

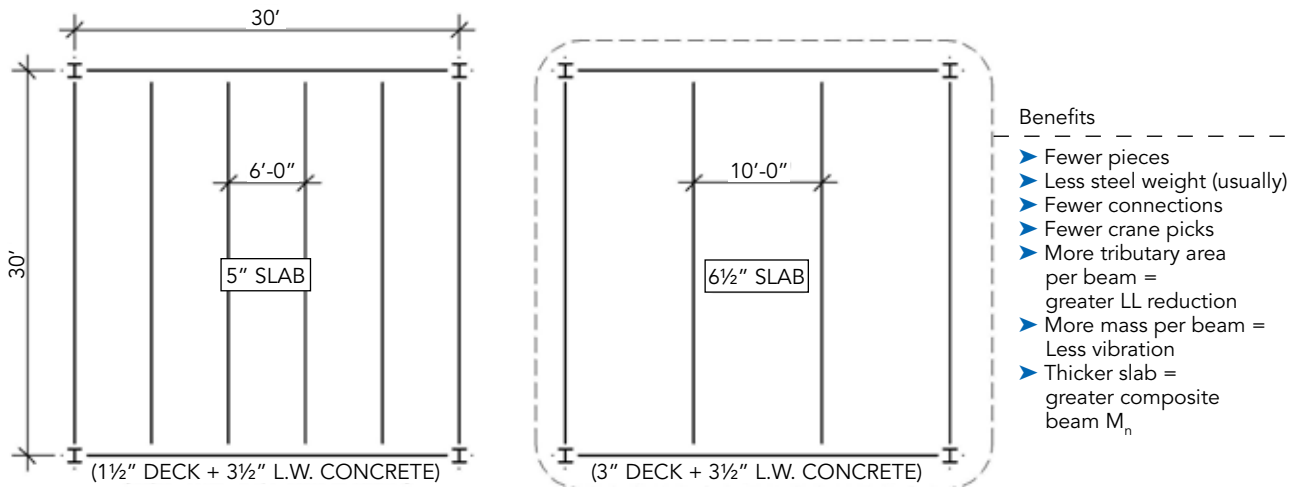
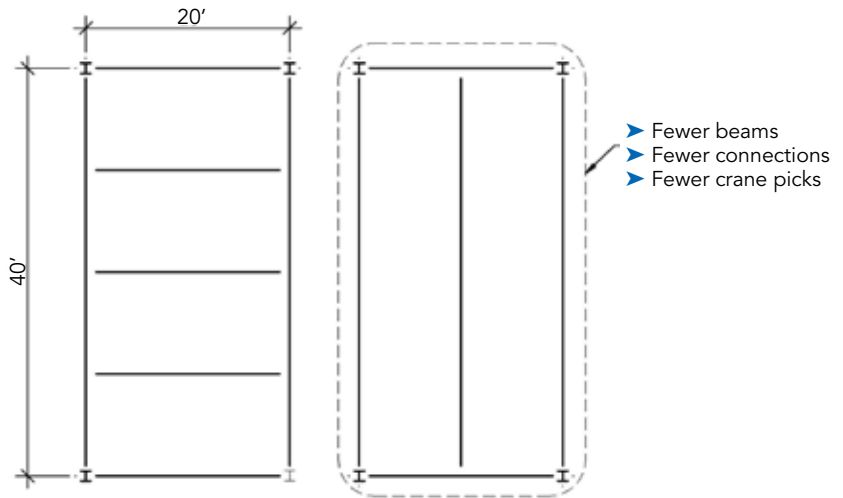
Tip 47: Minimize the “gingerbread”—extra small pieces of steel (Figure 32).

**Miscellaneous topics**

Tip 48: Avoid torsion in W shapes.

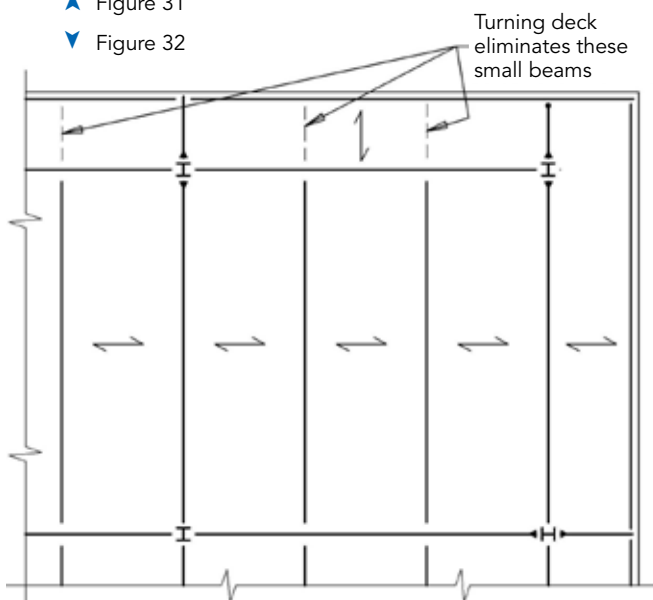
Tip 49: Use  $R=3$  and the associated basic seismic design without AISC 341 requirements, when possible.

Tip 50: Use camber intelligently. It often is more economical to design stiffer floors without camber.



▲ Figure 31

▼ Figure 32



Remember: The more choices the fabricator, erector and connection design engineer have available to them—and the earlier in the process they are able to provide input—the more likely they are to provide better solutions. Engage them early and they’ll help enhance your project’s constructability and success. ■

*Want more constructability and economy tips? You can view the related SteelDay 2012 webinar for free (and receive free CEUs or PDHs) at [www.aisc.org/50tips](http://www.aisc.org/50tips). You can also view the related 2013 NASCC presentation at [www.aisc.org/50tipsmmedia](http://www.aisc.org/50tipsmmedia). And Cliff Schwinger will be presenting sessions at this year’s NASCC: The Steel Conference, March 26-28 in Toronto, as well. Visit [www.aisc.org/nascc](http://www.aisc.org/nascc) to register and find out more about the show.*